

# Water Vapor and Cloud Detection Validation for Aqua Using Raman Lidars and AERI

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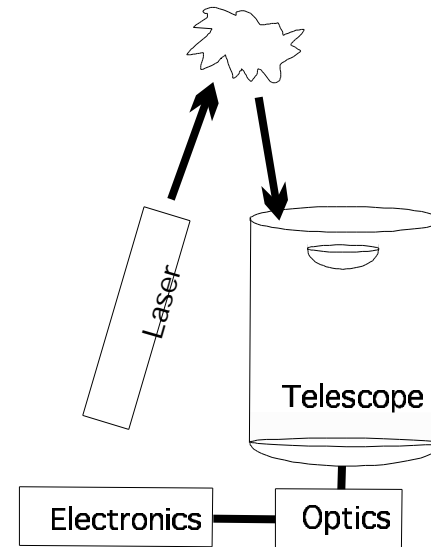
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# Overview

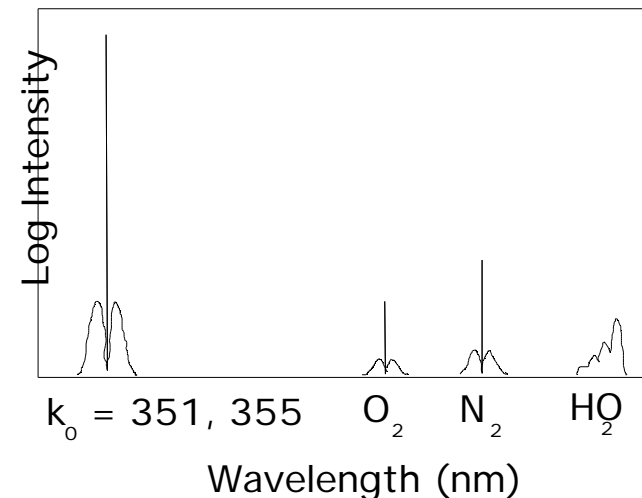
- Scanning Raman Lidar
- Revised Work Plan
  - Raman Airborne Spectroscopic Lidar (RASL)
- Influence of thin cirrus clouds on GOES retrievals
- SuomiNet GPS PWV intercomparisons

# Raman Lidar

- Laser transmitter (UV better)
  - excites Raman scattering in atmospheric species. Energy shifts and return wavelengths for 351, 355 excitation are:
    - $\text{O}_2$  ( $1555\text{ cm}^{-1}$ )  $\Rightarrow$  371, 375 nm
    - $\text{N}_2$  ( $2330\text{ cm}^{-1}$ )  $\Rightarrow$  382, 387 nm
    - $\text{H}_2\text{O}$  ( $3657\text{ cm}^{-1}$ )  $\Rightarrow$  403, 408 nm
- Telescope receiver
  - wavelength selection optics separate the wavelengths
- Time gated data acquisition gives range information



Rayleigh, Mie and Raman Signals



# NASA/GSFC Scanning Raman Lidar (SRL)

- Single trailer mobile system
- Two lasers: XeF excimer, Nd:YAG
- Horizontal 0.75 meter telescope aligned to scanning mirror
- Full aperture scanning capability
- Day and night measurements of water vapor, aerosols, clouds
- All weather operations



SRL on location at Andros Island, Bahamas  
for the third Convection and Moisture  
Experiment (CAMEX-3)

# Proposed Work Plan

- Scanning Raman Lidar proposed for participation in CAMEX-4
- Aqua validation exercises to occur CAMEX-4
  - Some personnel costs shared between CAMEX-4 and Aqua validation
- AQUA slip and CAMEX-4 budget constraints
  - SRL not funded for CAMEX-4
- Nonetheless (thank you!) we were funded for Aqua validation
  - Revised work plan required

# Revised Work Plan – Year 1

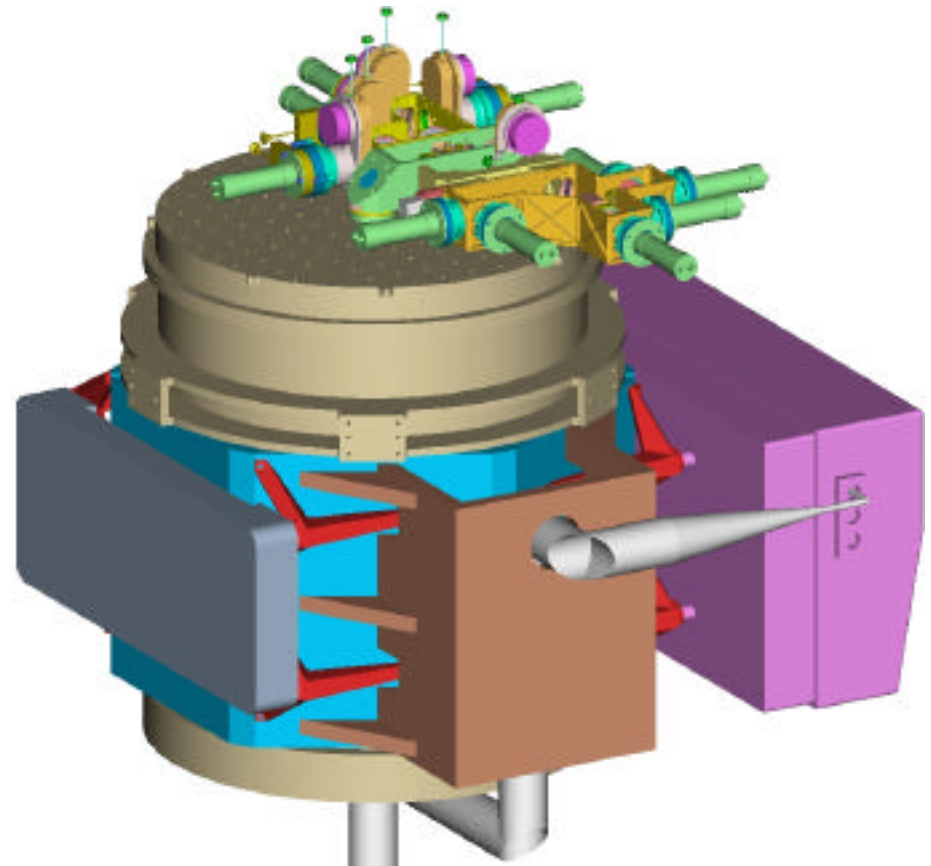
- Primary Goal
  - Rapid turnaround of calibrated Raman lidar UT water vapor profiles coordinated with AIRS overpasses during critical L+3 to L+5 window (June 24 – August 24) concentrating on clear conditions
  - Issues
    - SRL participation in IHOP (May 13 – June 20) possible
      - RASL from GSFC lab should be available for measurements as well
- Additional Goals
  - Study of existing SRL and AERI datasets to understand influence of cirrus clouds on high resolution FTIR spectra
    - WVIOP1, WVIOP2, CAMEX-3
    - Study particle size retrievals
  - Cross comparison of SRL and ALEX (UMBC) water vapor mixing ratio measurement
    - Co-located with BBAERI always

# Revised Work Plan – Years 2 and 3

- Primary Goal
  - Deploy SRL to UMBC during winter time
  - Acquire Raman Lidar UT water vapor measurements along with BBAERI spectra in coordination with AIRS overpasses
  - Study AIRS and GOES PWV retrievals in the presence of thin cirrus.
- New goal due to recently added capability
  - Raman Lidar Group recently became operational member of SuomiNet GPS PWV project
  - Work in process for nearly automated comparisons of SuomiNet GPS, GOES, MODIS and AERONET PWV
    - Will add AIRS when data available.

# RASL System Configuration

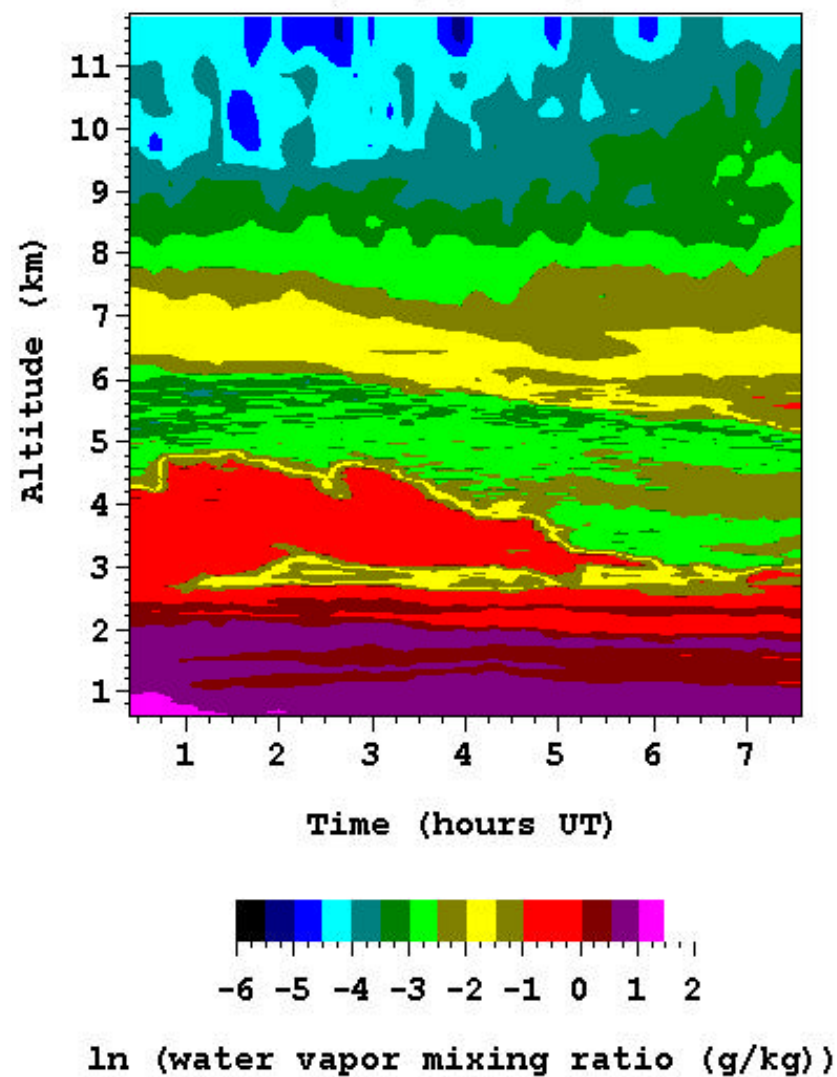
- Tripled Nd:YAG laser (17.5W)
- 24" athermal telescope
- A/D and PC data acquisition
  - 7.5 meter range resolution
- Raman channels
  - Water vapor
  - Liquid water
  - Nitrogen
  - Oxygen
- Elastic channels
  - Unpolarized
  - Parallel polarized
  - Perpendicular polarized
- Designed for
  - Cargo bay of DC-8 and P3 passenger compartment
  - Can be made compatible with C-130, ER-2, WB-57



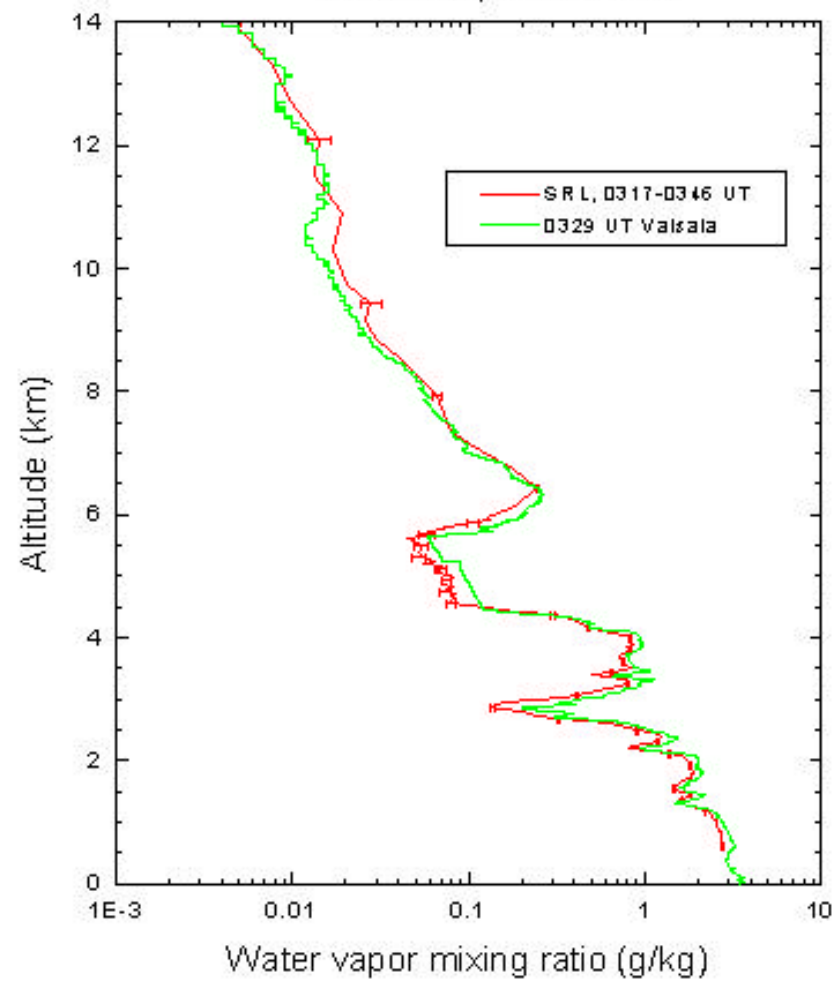
*As a system, RASL represents a dramatic increase in airborne remote sensing capability over any existing instrument*



GSFC SRL, 12/5/2000, ARM CART

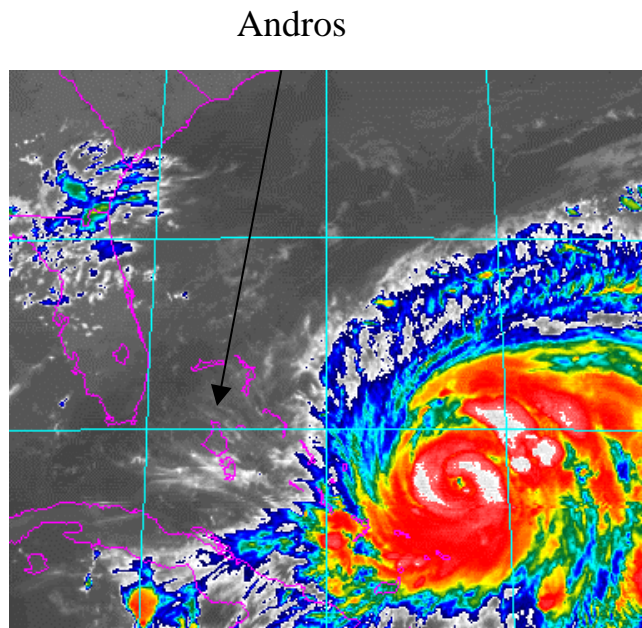


12/5/2000, ARM CART

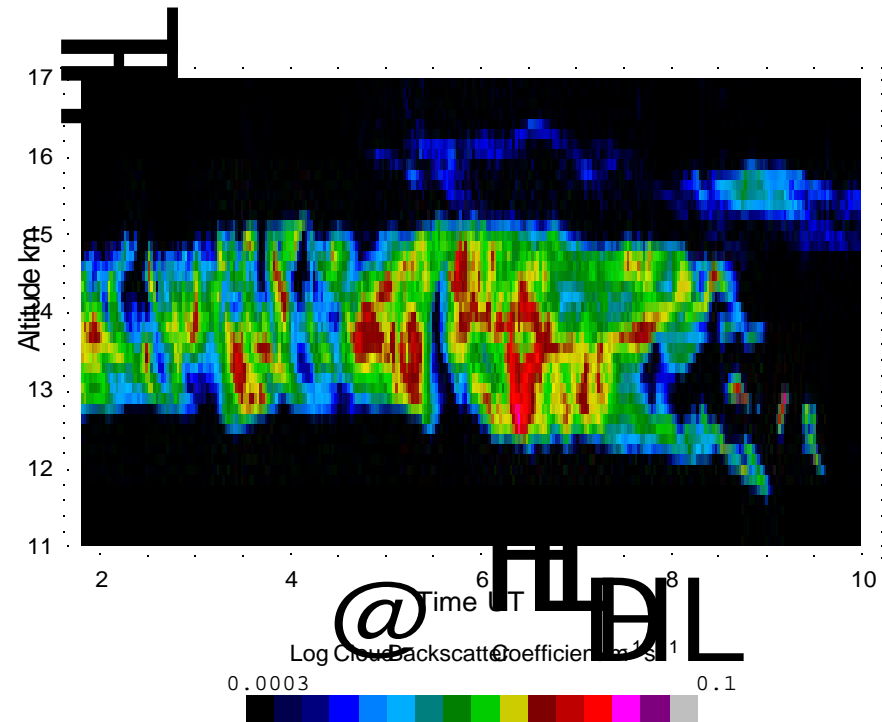


# Hurricane Bonnie Induced Cirrus Cloud

## August 23, 1998 - CAMEX3



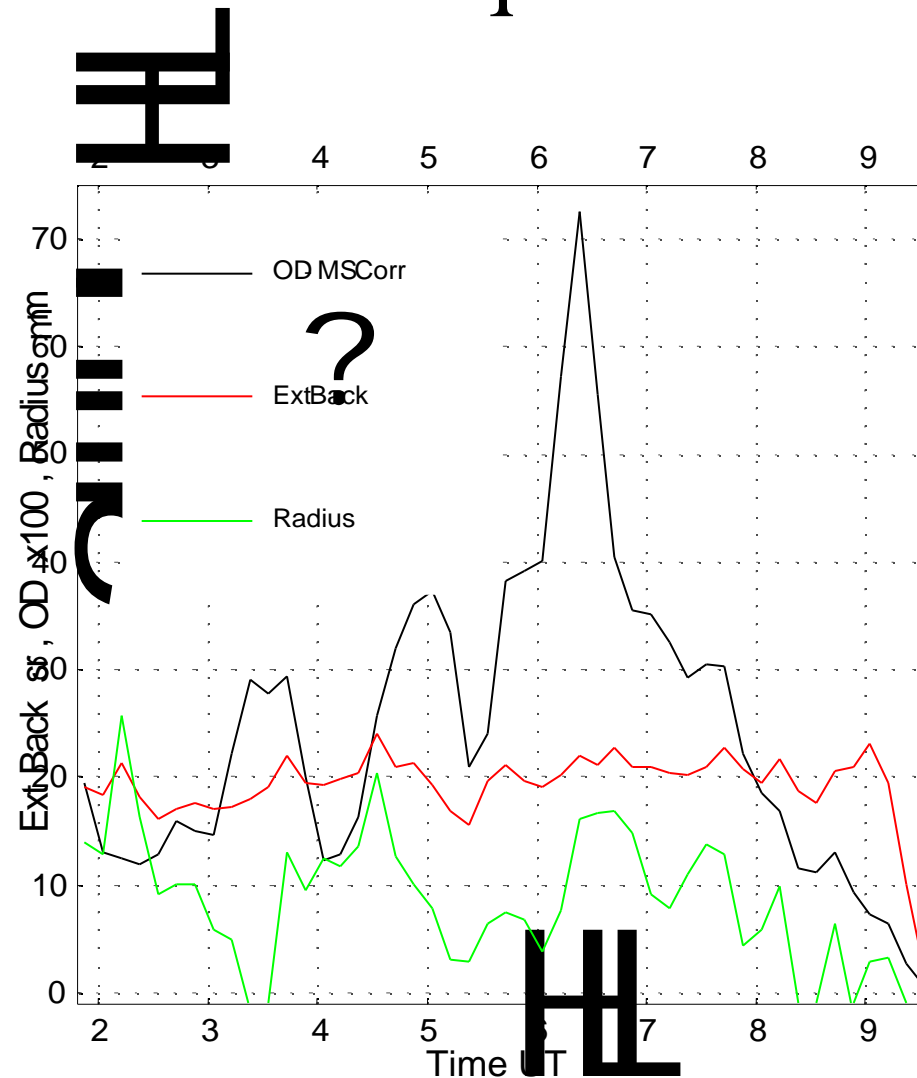
GOES infrared image



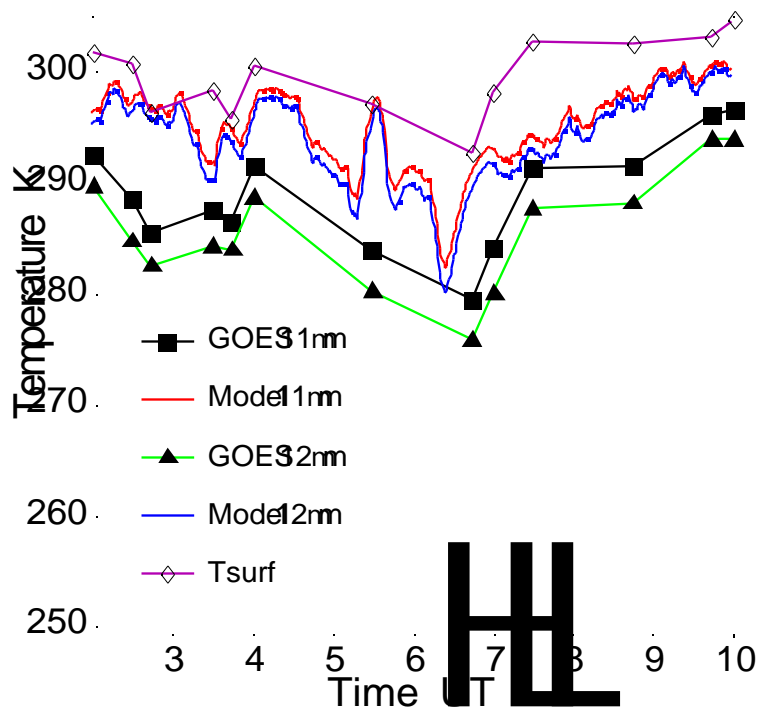
Cirrus cloud backscatter coefficient

# Cirrus Retrieval Technique

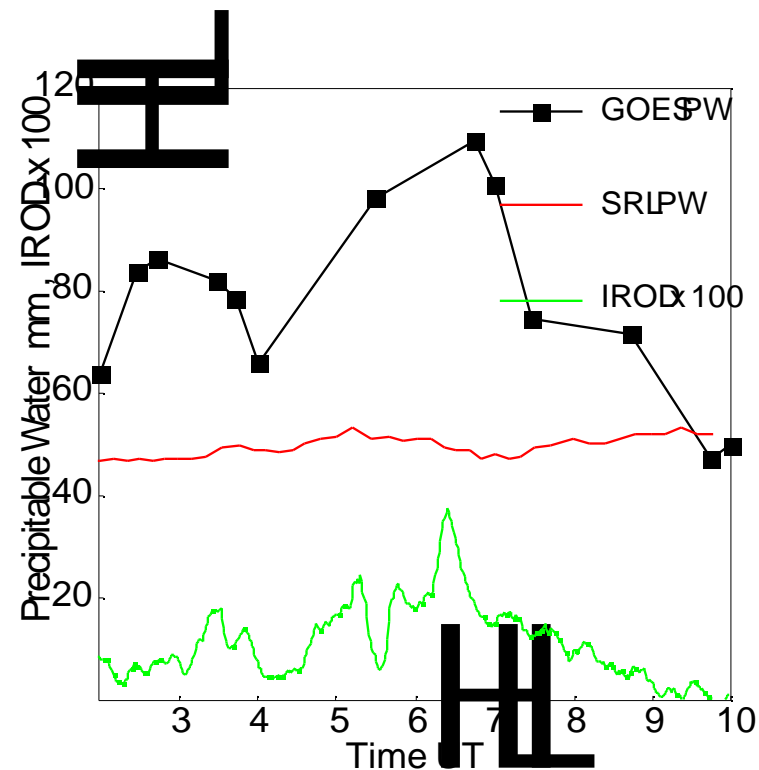
- An iterative solution was developed for the following:
  - multiple scattering in the cloud
  - layer average extinction/backscatter ratio
  - layer average diffraction equivalent particle radius
- Now the influence of cirrus clouds on satellite measurements can be studied.



# SRL Measured and GOES-Retrieved TPW



Radiative transfer model calculations compared with GOES radiances and retrieved skin temperature.



GOES retrieved TPW compared with SRL TPW. Cirrus OD (IR) is also shown.

*Using the latest ISCCP cloud detection thresholds, this case study indicates a high bias in retrieved TPW of up to 20% over water and 40% over land due to undetected cirrus clouds.*

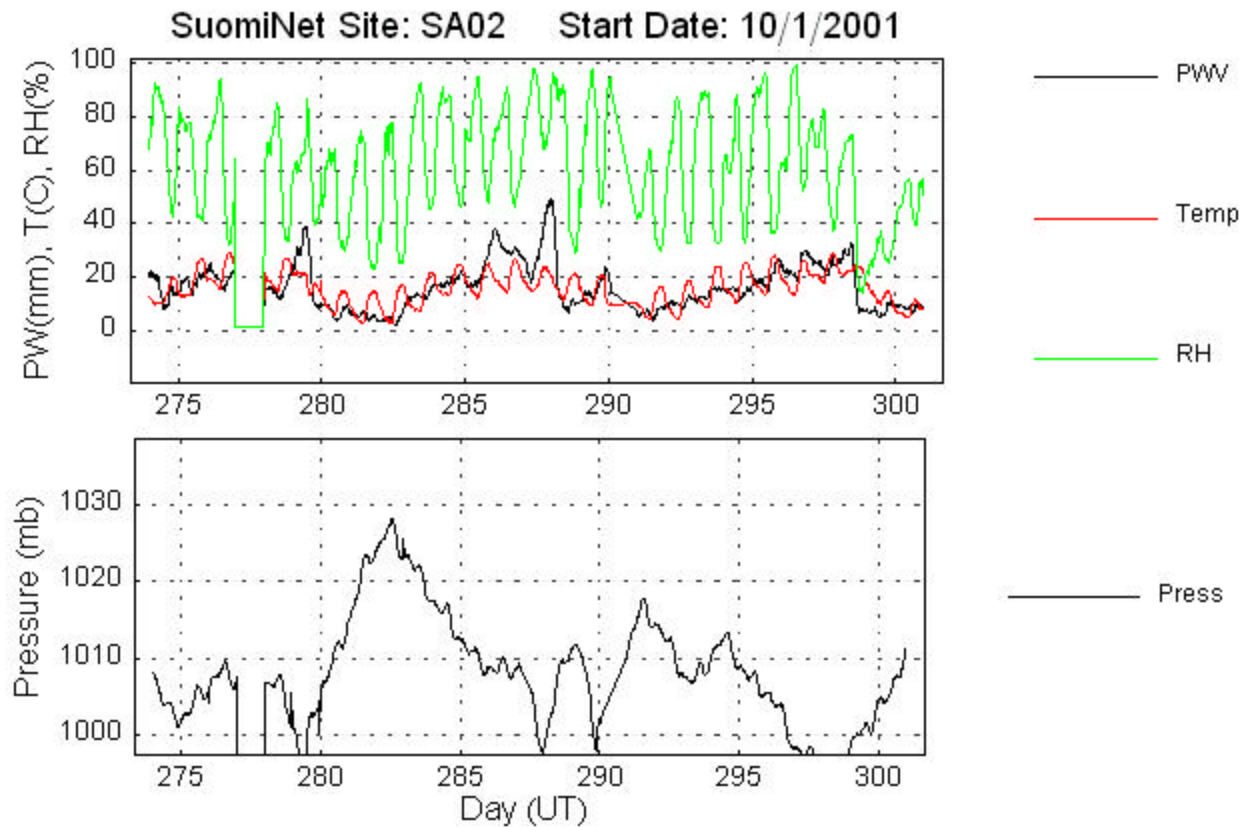
# Cirrus influence on satellite radiances

- GOES is sensitive to cirrus at the  $> 0.005$  optical level
- EOS Science plan (King et al, 1999) indicates that EOS sensors need to be able to detect cirrus down to the 0.05 level
  - if the EOS satellites discriminate clouds with this sensitivity there can be significant influence due to undetected cirrus
- ISCCP cirrus detection threshold implies errors in GOES TPW retrievals due to undetected cirrus
  - up to 20% over water (OD  $\sim 0.05$ )
  - up to 40% over land (OD  $\sim 0.1$ )



# GSFC SuomiNet GPS

- On line August 15, 2001
- Automation of comparisons with MODIS, GOES, AERONET in process
- Will add AIRS when available
- Other sites possible
  - e.g. NOAA site LMNO about 7 km from the SuomiNet site SG01



# Summary

- Year 1: primary activity will be to provide calibrated UT water vapor retrievals during AIRS overpasses
  - We will also study existing SRL and AERI data to better understand the influence of cirrus clouds on high resolution IR spectra
    - Goal: cirrus cloud products
- Years 2 and 3: deployment of SRL to UMBC for combined Raman Lidar/BBAERI measurements during AIRS overpasses in the presence of cirrus clouds
- PWV Comparisons: SuomiNet GPS, GOES, MODIS, AERONET, AIRS (when available)